Evolution of an Iron Film on GaAs(001)-4x6

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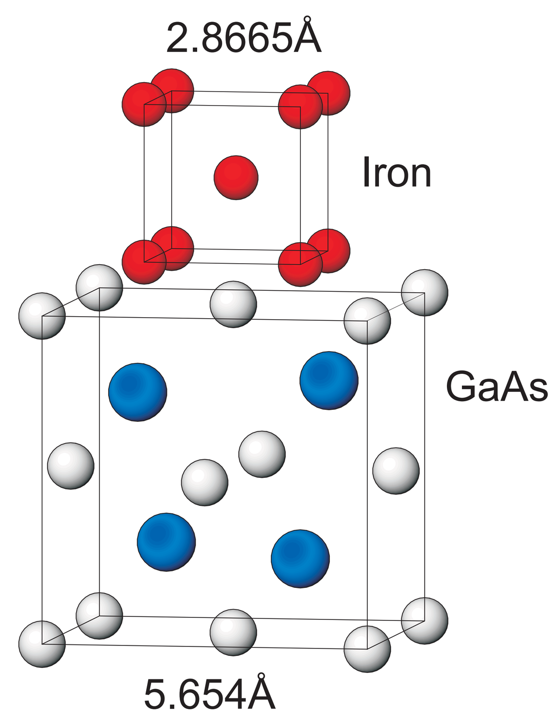
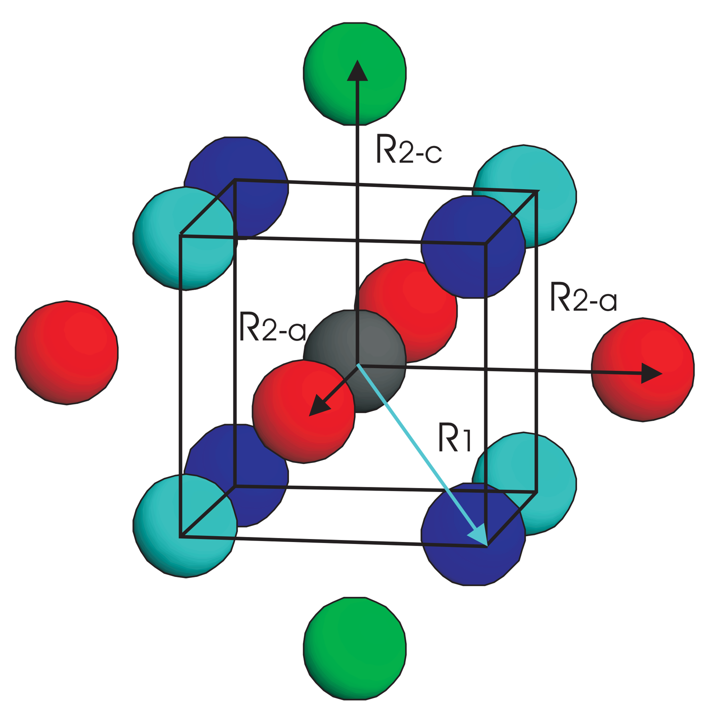
Introduction:

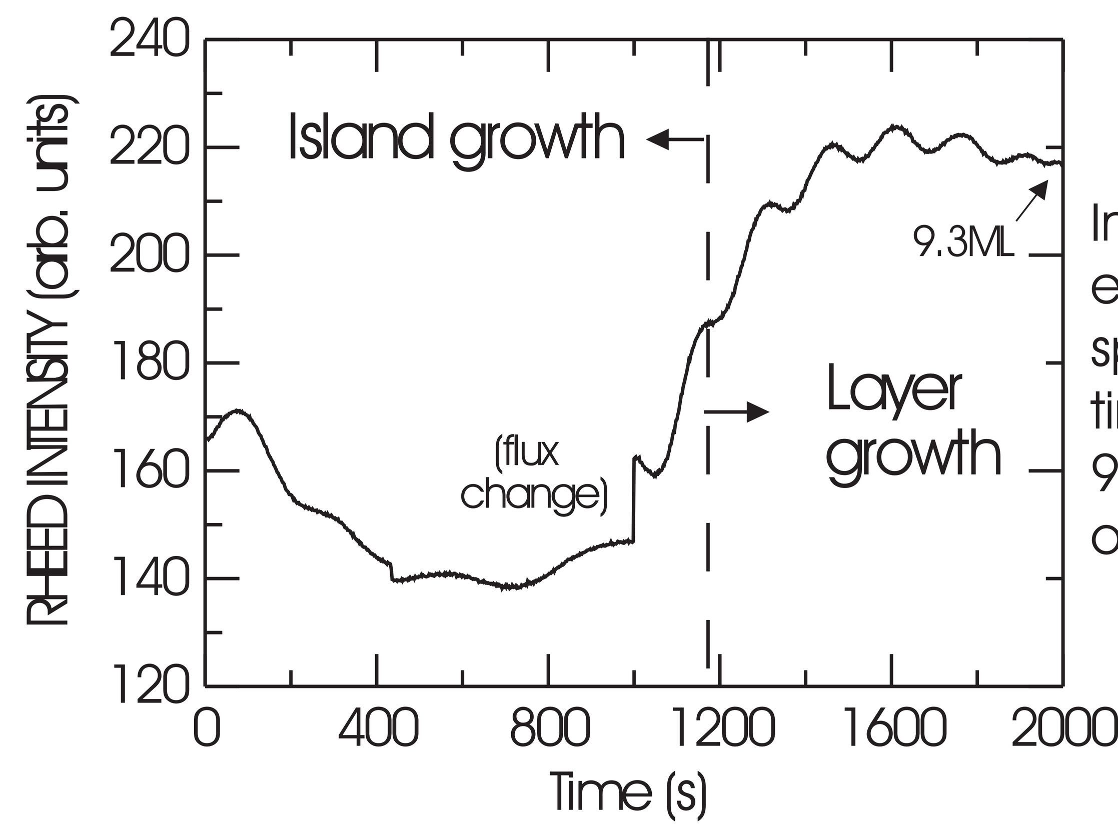
The small mismatch (1.4%) between the lattices of Fe and GaAs has stimulated considerable interest in the field of magnetic nanostructures. Using the Ga-rich 4x6 reconstruction of the GaAs(001) surface can result in high-quality iron films [1]. What is missing is an understanding of how the structure evolves with increasing thickness.





Polarization-dependent XAFS:

By orienting the X-ray polarization along (001), we select out R_1 (all blue) and $R_{2\text{-}c}$ (green), which is the c-axis distance. With the polarization along (110), we extract R_1 (dark blue) and the average $R_{2\text{-}a}$, the in-plane lattice constant (all red).



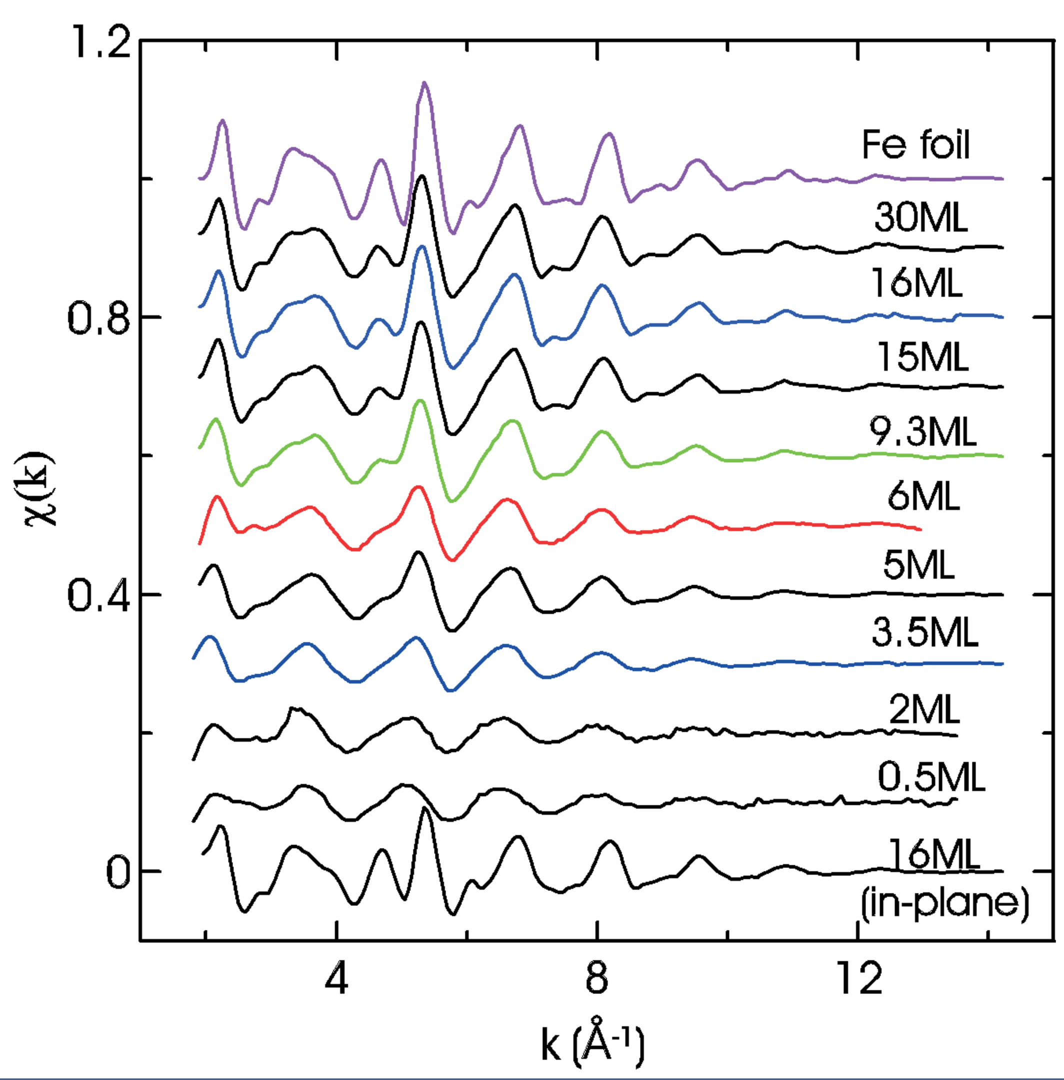
Intensity of reflected electron diffraction spot as a function of time during growth of 9.3 monolayers of Fe on GaAs

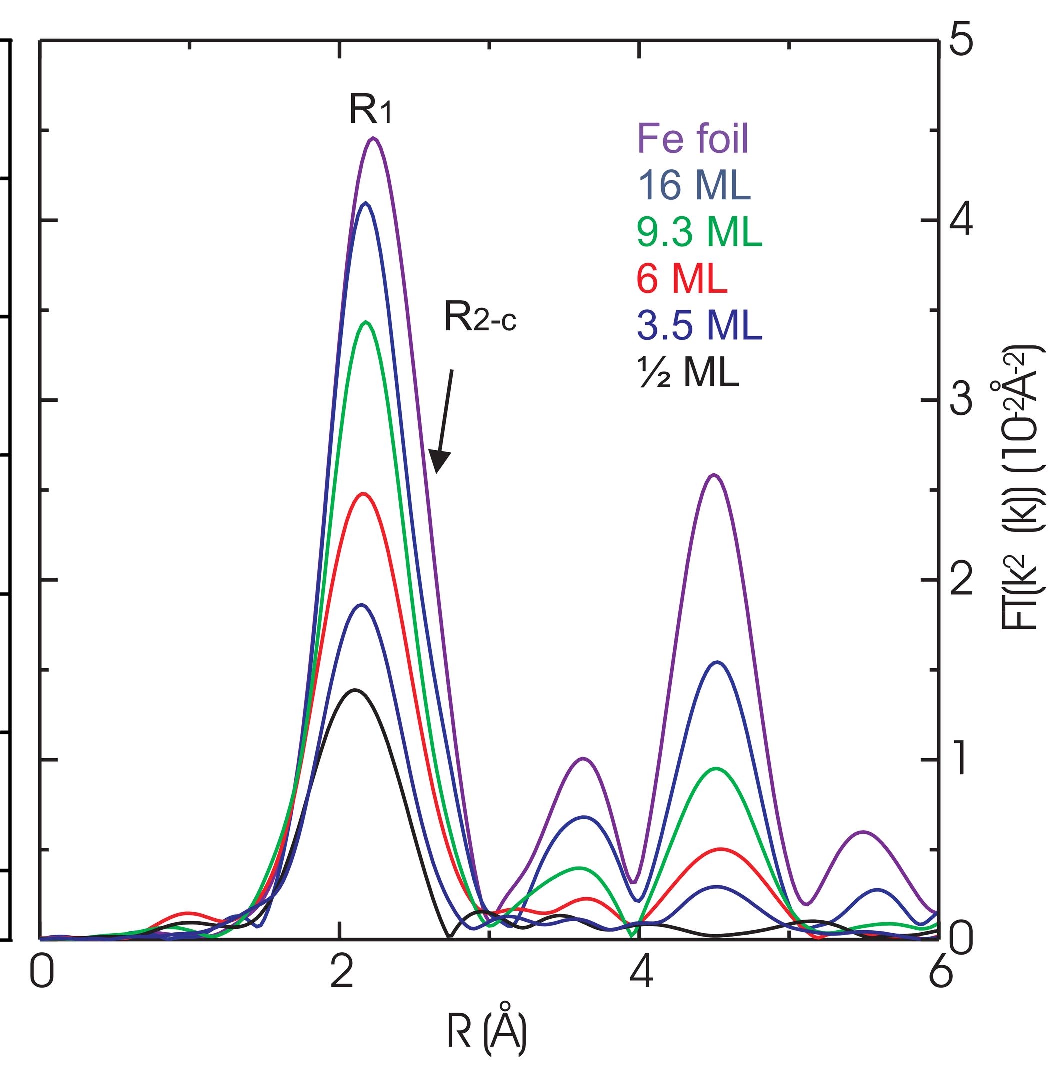
Experimental:

Epitaxial growth proceeds through a transition from island to layer-by-layer near 4 monolayer-equivalent deposition. Using the Molecular Beam Epitaxy facility of the Pacific Northwest Consortium Collaborative Access Team (APS, Argonne National Laboratory), a number of films with thicknesses above and below this transition were prepared and measured in total reflection mode *in-situ* using fluorescence and electron yield.

Results:

Previous work has shown the existence of a body-centred tetragonal distortion of the Fe with a *c/a* ratio near 1.03 [2] at 9.3 monolayers. The out-of-plane data show pronounced differences from the in-plane (16 ML example shown) and body-centred cubic Fe foil as a result of this distortion. We focus on out-of-plane data as the strongest indicator of this distortion.



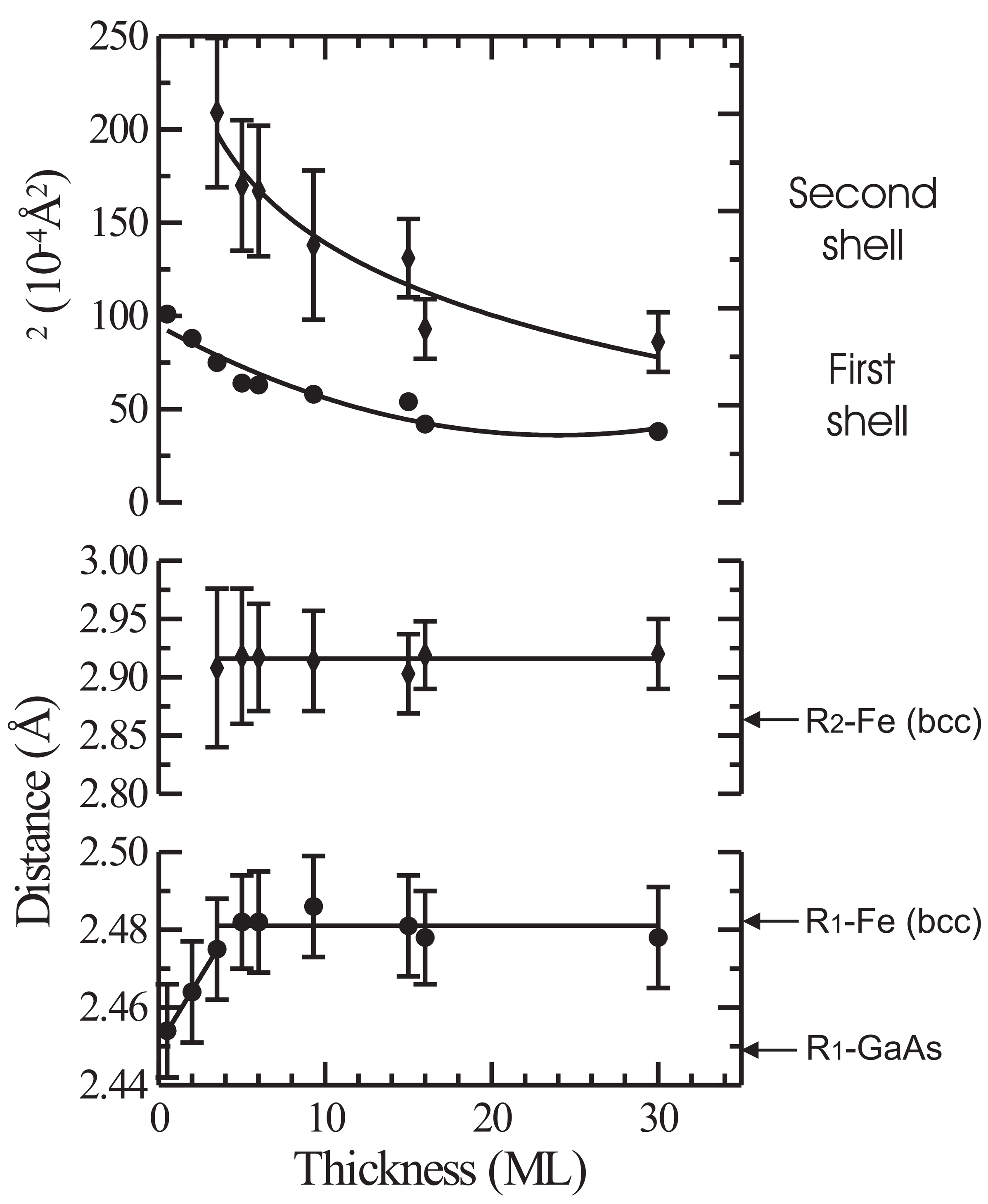


Increasing film thickness manifests as increasing amplitude in higher shells in the Fourier transform at left. The first peak in the FT contains both the nearest neighbour and c-lattice constant distances. Analysis of this peak was done to identify how the structure evolves with increasing thickness.

For each thickness, n, the first peak in the transform was fit assuming a model of n monolayers of Fe capped below by Ga (for the Ga-rich reconstructed surface) and above by As (for As diffusion to the surface). Co-ordination numbers were fixed according to this model, with first and second shell parameters (distance, mean-square-relative-displacement) determined as shown at right. Second shell information could not be extracted from the two thinnest samples.

In the layer-growth regime, we observe a remarkably constant distortion to body-centred tetragonal out to 30 ML, the highest thickness measured.

Below the transition in growth modes, we observe a decreasing R_1 distance with decreasing thickness, approaching the nearest-neighbour distance in GaAs for the ½ ML sample, indicating some interdiffusion with the substrate at low film coverage.



Acknowledgments

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References

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2. Gordon, R.A., Crozier, E.D., Jiang, D.-T., Monchesky, T.L. And Heinrich, B., Phys. Rev. B **62**, 2151 (2000)

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